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AUTHOR(S):

Hadano, Kazuo; Hirakawa, Akina; Hamanaka, Toshihiko; Ohashi, Hiroshi; Ohigashi, Yoshitaka; Morimune, Susumu

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A study of Aphasia by Factor Analysis

Kazuo HADANO, Akina HIRAKAWA,
Toshihiko HAMANAKA, Hiroshi OHASHI,
Yoshitaka, OHIGASHI and Susumu MORIMUNE

I Introduction

In this study, we would like to quantify speech symptoms and analyse a set of these quantitatively assessed symptoms as multivariate data by the method of factor analysis. Our main purpose is to reexamine the classification of aphasic syndromes based upon the concept of "fluency" in aphasia, which was introduced into modern aphasiology by American neuropsychologists such as Goodglass and Benson.

"Fluency" or "non-fluency" in aphasic speech is essentially assessed by the whole clinical impression that the conversational or spontaneous speech of aphasic patients gives the examiner. The concept of "non-fluency" may consist of the following characteristics in aphasic speech; short phrase length, disturbance of articulation, dysprosody, simplification of grammatical forms, small amount of speech production, etc. When some of these symptoms are observed, a patient's speech gives an impression of "non-fluency" and we diagnose "non-fluent aphasia". Other symptoms—for example, disturbance of comprehension, echolalia, etc. —may not be empirically related to the concept of "non-fluency". Accordingly, if the variables of appropriately quantified symptoms are factor analysed, a factor interpretable as "fluency" can be found, and the symptoms which are not related to—statistically independent of—the factor "fluency", can be pointed out by the same procedure. With this factor analysis as background we then reexamine our clinical classification of aphasia from operationalistic view point.

II Subjects

The subjects in this study are the aphasic patients in our three clinics, that is, Dept. of Neuropsychiatry, Kyoto Univ. Hospital, Dept. of Neuropsychiatry, Kyoto First Red Cross Hospital and Kyoto City Rehabilitation Center for the Handicapped.

Kazuo HADANO (波多野和夫): Dept. of Biomedical Informatics, Medical Faculty, Kyoto University & Dept. of Neuropsychiatry, Kyoto First Red Cross Hospital
Akina HARAKAWA (平川顕名): Dept. of Biomedical Informatics, Medical Faculty, Kyoto University.
Toshihiko HAMANAKA (浜中淑彦), Hiroshi OHASHI (大橋博司): Dept. of Neuropsychiatry, Medical Faculty, Kyoto University.
Yoshitaka OHIGASHI (大東祥孝): Center of Student Health, Kyoto University.
Susumu MORIMUNE (森宗 勧): Kyoto City Rehabilitation Center for the Handicapped.

117 aphasic patients were selected based on the following criteria: patient is (1) right-handed, (2) medically diagnosed as cerebral infarction, (3) evaluated by SLTA (Standard Language Test of Aphasia), which is the most widely used psychometric test-battery in Japanese aphasiology, and (4) conversational speech at a semi-standardized interview conducted by an examiner concerning the patient's name, address, birthday, age, hobbies, occupation, home town, etc., recorded onto casette-tapes. The localization of lesions in all cases was verified by CT-scan findings.

The mean age of the subjects was 59.3 years old (the standard deviation 17.6 years). The mean duration of the disease was 6.4 months (the standard deviation 10.5 months).

117 aphasics were grouped in several aphasic types by two systems of classification: (1) Classification based upon fluency; a fluent aphasia group of 53 cases, a non-fluent aphasia group of 39 cases, and an intermediate group 25 cases, which could be diagnosed distinctly neither as typically fluent nor typically non-fluent aphasia. (2) Classification according to the notion of classical aphasic syndromes (Ohashi 1965); Wernicke aphasia 29 cases, Neologistic jargonaphasia (Hadano et al. 1984) 4 cases, Amnestic aphasia 7 cases, Conduction aphasia 4 cases, Total aphasia 6 cases, Broca aphasia 28 cases (the Broca aphasia group was broken down as follows: Severe Broca 11, Typical Broca 5, Atypical Broca 6, and Mild Broca with anarthria 6 cases), Residual aphasia 9 cases, and other types of aphasia including transcortical types and unclassified aphasia 30 cases. These classifications of aphasic groups were determined by the consensus among us based both on our clinical impression of the patients' speech behaviour in free conversation and the results of language tests.

III Methods and Results

43 variables were included in the factor analysis, for the purpose of grasping as many aspects of aphasic disturbances as possible in the conversational situations. Table 1 shows the list of variables. Cassette-tapes of the patients' conversation were played back and the language characteristics on the 43 rating scales were assessed exactly.

The set of variables consisted of 8 variables (GOOD1–GOOD8) from the rating scales of Aphasia Severity and Speech Characteristics in the Boston Diagnostic Aphasia Examination (BDAE, Goodglass-Kaplan 1972), 6 variables (POE1–POE6) from the rating scales of Spontansprache in Aachener Aphasietest (AAT, Poeck 1982), 28 variables introduced by ourselves in this study, and 1 variable, named Y2, from SLTA (the sum of scores of Subtest 1–3) as a index of auditory comprehension. We had to adopt this variable, because the quantitative evaluation of auditory comprehension disturbances in conversational speech is very difficult using only playbacks of casette-tapes. The variables from the BDAE and AAT were assessed in the standard manner. Of the 28 variables introduced by us, 23 symptoms (ANT-

Table 1. List of Variables

GOOD1	Aphasia Severity (BDAE)	[0–5]	ANT	Loss of Speech Initiative	[0–3]
GOOD2	Melodic Line (BDAE)	[1–7]	PRES	Pressure of Speech	[0–3]
GOOD3	Phrase Length (BDAE)	[1–7]	STUT	Stuttering	[0–3]
GOOD4	Articulatory Agility (BDAE)	[1–7]	HYP	Hypophonia	[0–3]
GOOD5	Grammatical Form (BDAE)	[1–7]	HOAS	Hoarseness	[0–3]
GOOD6	Paraphasia (BDAE)	[1–7]	BRAD	Bradylalia	[0–3]
GOOD7	Word Finding (BDAE)	[1–7]	TACH	Tachyphemia	[0–3]
GOOD8	Auditory Comprehension (BDAE)	[1–7]	MONO	Monotony	[0–3]
			DYST	Dystony	[0–3]
POE1	Kommunikationsverhalten (AAT)	[1–6]	ART	Severity of Dysarthria	[0–3]
POE2	Artikulation und Prosodie (AAT)	[1–6]	ARTFR	Frequency of Dysarthria	[0–4]
POE3	Automatisierte Sprache (AAT)	[1–6]	AGR1	One-Word Speech	[0–3]
POE4	Semantische Struktur (AAT)	[1–6]	AGR2	Loss of Auxiliary Word	[0–3]
POE5	Phonematische Struktur (AAT)	[1–6]	AGR3	Poverty of Conjugation	[0–3]
POE6	Syntaktische Struktur (AAT)	[1–6]	AGR4	Error of Conjugation	[0–3]
			PARAG	Paragrammatism	[0–3]
Y2	Auditory Comprehension (SLTA)	[0–30]	REC	Recurring Utterance	[0–3]
			AUTOM	Speech Automatism	[0–3]
SYL	Syllables per min.		STER	Verbal Stereotypy	[0–3]
WO	Words per min.		EMPT	Empty Phrase	[0–3]
PHR	Phrases per min.		SYLLA	Syllalia : Mitsprechen	[0–3]
FR	Fragmentary Syllables per min.		ECHO	Echolalia	[0–3]
PARA	Paraphasias per min.		EFF	Effortful Speech	[0–3]

EFF), which are shown on the right half of Table 1, were scored by the following ordered scale: if the symptom was not present, 0; if suspected or mild, 1; if recognized clearly, 2; if severe, 3. 5 variables (SYL-PARA), which are listed in the lower left part of Table 1, represent directly the total number per minute of syllables, words, phrases (so-called Bunsetsu in Japanese grammer), fragmental syllables, and all kinds of paraphasia. These 5 variables indicate the amount of speech production per minute.

Computer program "FACTOR" in SPSS (Statistical Package for the Social Sciences, Kyoto University Version, Miyake et al. 1976) was used for the factor analysis in this study. After the factors, whose eigenvalues were 1.0 or larger, were extracted by the principal component method, Varimax rotated factor matrix (Table 2) and factor scores of each case were obtained as output.

Because Varimax rotation is orthogonal, factor loadings are equal to correlation coefficients between the factor and variables. In this Table factor loadings larger than 0.5 are marked with black dots in order to make the interpretation of factors more easily.

Table 2. Varimax Rotated Factor Matrix

	FACTOR 1	FACTOR 2	FACTOR 3	FACTOR 4	FACTOR 5	FACTOR 6	FACTOR 7	FACTOR 8	FACTOR 9	FACTOR 10
GOOD1	0.38231	0.79764●	0.23142	0.17851	-0.07939	-0.01509	0.06648	-0.02032	0.06749	0.00441
GOOD2	0.91642●	0.25999	0.03318	0.13218	-0.10100	0.00801	0.11716	-0.09320	-0.00587	-0.00599
GOOD3	0.81849●	0.38919	-0.03154	0.20166	-0.14680	-0.07196	0.09785	-0.10182	0.13029	-0.03751
GOOD4	0.86589●	0.32925	0.01268	0.12180	-0.19430	0.06690	0.04040	-0.09538	-0.11106	-0.00156
GOOD5	0.78401●	0.46446	0.06146	0.08251	-0.14192	0.01323	0.09400	-0.12890	0.19812	-0.09720
GOOD6	0.01514	0.14678	0.76672●	0.02934	-0.15204	-0.09743	-0.04850	-0.04269	-0.14382	-0.03838
GOOD7	-0.57560●	0.18206	0.39732	-0.13708	-0.01785	0.08950	-0.25249	0.09165	-0.05753	0.12279
GOOD8	0.00673	0.85020●	0.05972	0.01084	-0.12319	-0.05284	0.06388	0.00544	-0.17217	0.09074
Y2	-0.01314	0.88164●	0.06074	0.02180	-0.10334	-0.03674	0.02054	0.03265	-0.13014	0.11063
POE1	0.38758	0.79873●	0.23676	0.17851	-0.07283	-0.00934	0.08009	-0.01514	0.06272	0.01511
POE2	0.88666●	0.26603	-0.02392	0.13020	-0.18327	0.03187	0.01507	-0.05116	-0.14984	0.04579
POE3	0.18909	0.39490	0.01967	0.06243	-0.36332	0.09327	0.14628	-0.01103	0.21306	0.73583●
POE4	0.30625	0.72022●	0.33506	0.04651	-0.18982	0.21828	0.06457	0.01227	0.04843	0.14354
POE5	0.30937	0.44257	0.58289●	0.17428	-0.10224	0.12954	0.06212	-0.02887	0.13851	0.16327
POE6	0.66506●	0.57835●	0.14491	0.09372	-0.10824	0.00063	0.09611	-0.09255	0.14408	-0.02689
SYL	0.52280●	0.39597	-0.08692	0.70136●	-0.07350	-0.11041	0.10498	-0.00776	0.11150	0.04362
WO	0.54454●	0.31267	-0.00966	0.69884●	-0.07321	-0.14677	0.13011	-0.06555	0.10819	-0.01505
PHR	0.50808●	0.33536	-0.14078	0.70160●	-0.08025	-0.05932	0.22467	0.03422	0.07571	-0.06508
FR	-0.22475	0.01061	-0.23864	-0.14234	0.12171	0.51794●	-0.03820	-0.01557	-0.00728	-0.00724
PARA	0.09047	-0.17014	-0.78330●	0.27416	-0.07796	0.09354	0.07160	0.07733	0.04172	0.08623
ANT	-0.41356	-0.34922	0.19919	-0.15951	0.01856	-0.04295	-0.49798	-0.03084	-0.08884	0.10642
PRES	0.21436	-0.18986	-0.45391	0.46448	0.06319	0.04229	0.02113	0.03683	0.10857	-0.04527
STUT	0.00468	0.23963	-0.21865	-0.12061	-0.19232	0.73584●	0.07880	0.05760	0.16590	-0.15647
HYP	-0.34870	-0.24743	0.07134	-0.19808	0.04595	-0.20761	-0.64456●	-0.11248	0.12827	0.00548
HOAS	-0.29957	-0.28560	-0.03271	-0.06154	0.37366	0.00968	-0.48447	-0.01900	0.25079	-0.03111
BRAD	-0.76276●	0.10735	-0.11022	-0.07465	-0.16859	0.12850	-0.05378	-0.15076	-0.10165	-0.02353
TACH	0.00988	-0.09743	-0.03254	0.09412	-0.00271	-0.01426	-0.02249	0.01214	0.46000	0.11637
MONO	-0.81344●	0.04359	-0.07356	-0.07216	-0.24682	0.03949	-0.22075	-0.16516	0.03041	-0.07760
DYST	-0.49174	-0.13398	-0.10506	-0.09875	0.33280	0.08903	0.27205	0.23016	0.22526	0.02822
ART	-0.85448●	-0.17555	0.01235	-0.13137	0.18148	-0.00306	0.00818	0.17661	0.26635	-0.11370
ARTFR	-0.83778●	-0.25568	-0.03782	-0.13549	0.18820	-0.06068	-0.02438	0.11445	0.24445	-0.03976
AGR1	-0.68950●	-0.28724	-0.01951	-0.05688	0.15920	0.16493	-0.13324	0.27391	-0.26542	0.24320
AGR2	-0.17826	0.16746	-0.08439	0.03818	-0.14630	-0.06945	0.10076	0.62588●	-0.02613	-0.03310
AGR3	-0.18419	-0.17094	-0.04105	-0.03381	0.20036	-0.02457	-0.04457	0.68426●	-0.12019	-0.07342
AGR4	-0.01049	0.03354	-0.04002	0.00628	-0.06634	0.05532	-0.03207	-0.07447	0.30609	0.00268
PARAG	0.55916●	-0.10629	-0.11224	0.07760	-0.15495	-0.01166	0.00502	-0.25086	0.19707	0.03132
REC	-0.15934	-0.14690	-0.20581	-0.06676	0.73318●	-0.08657	-0.09670	0.04677	-0.09290	-0.07265
AUTOM	-0.16648	-0.15195	-0.02520	0.02504	0.27092	-0.12798	0.31654	-0.06678	-0.04723	-0.22594
STER	0.17405	-0.06209	0.03822	0.06722	-0.01737	0.15456	0.17805	0.13437	-0.09888	-0.41603
EMPT	0.53735●	-0.13552	-0.12742	0.22247	-0.11902	0.04066	0.12671	-0.09618	0.15042	-0.01892
SYLLA	-0.27158	-0.27965	0.09175	0.02047	0.53112●	0.22722	0.04881	0.00602	-0.23579	-0.10848
ECHO	0.01486	-0.14218	0.20159	0.10556	0.01435	0.46550	0.03678	-0.12345	0.00202	0.05029
EFF	-0.51673●	-0.09401	-0.02779	-0.15294	0.27899	0.32002	0.09068	0.03381	0.00071	0.01713

IV INTERPRETATION OF FACTORS

The variables that loaded on Factor 1 concerned chiefly speech symptoms of articulatory disturbance (GOOD4, POE2, ART, ARTFR), dysprosody (GOOD2, POE2, BRAD, MONO), phrase length (GOOD3), grammatical or syntactical disabilities (GOOD5, POE6, AGR1, PARAG), empty phrase (EMPT), effortful speech (EFF), and the amounts of speech production (SYL, WO, PHR). Factor 1 clearly corresponds closely with the contents of the impression of what is usually called "fluency" in aphasic speech. Accordingly, this factor can be labelled as Factor "Fluency".

Factor 2 was loaded for the variables of communicability (GOOD1, POE1), auditory comprehension (GOOD8, Y2) and general language abilities (POE4, POE5, POE6—semantic, phonematic and syntactic abilities). This factor may be considered as "Communicability".

Factor 3 can be interpreted as "Paraphasia", Factor 4 as "Speech production", Factor 5 as some kinds of "Automatic speech", Factor 6 as "Stuttering", and so on.

V DISCUSSION

From the results of our factor analysis, it may be concluded that communicability, paraphasia and stuttering are independent of fluency.

The 3 variables of speech production (SYL, WO, PHR) have not only high correlations with Factor 4, but also are closely correlated to Factor 1 "Fluency". This can be explained if the amount of speech production has two aspects, one of which is related to fluency, and the other not. Accordingly, an aphasic with low speech production may not always be considered to exhibit non-fluent aphasia. This conclusion is not inconsistent with our clinical experience.

This factor analysis offers the possibility of quantifying fluency in aphasic speech. As already mentioned, fluency is essentially a general clinical impression of the oral expression of patients. Some authors have attempted to quantify fluency. For example, Benson (1967) made rating scales for 10 clinical characteristics of aphasic speech and defined the arithmetic sum of these 10 rating scores as a fluency scale. The frequency polygon of Benson (1967) shows a clear bimodal or two-peak distribution of fluency. The one peak corresponds to the non-fluent aphasia group and the other peak to the fluent aphasia group.

In this study we define fluency by the factor score for Factor 1, labelled "Fluency". Fig. 1 is the histogram, which shows the distribution of fluency, as just defined. The two-peak distribution corresponding to the fluent and the non-fluent aphasia groups cannot be found as clearly as in Benson's figure.

Our result shows, that there is a continuum between fluency and non-fluency in aphasic speech. Accordingly, fluent aphasia and non-fluent aphasia connot be divided so clearly as Benson proposed. These results also supported the claim that

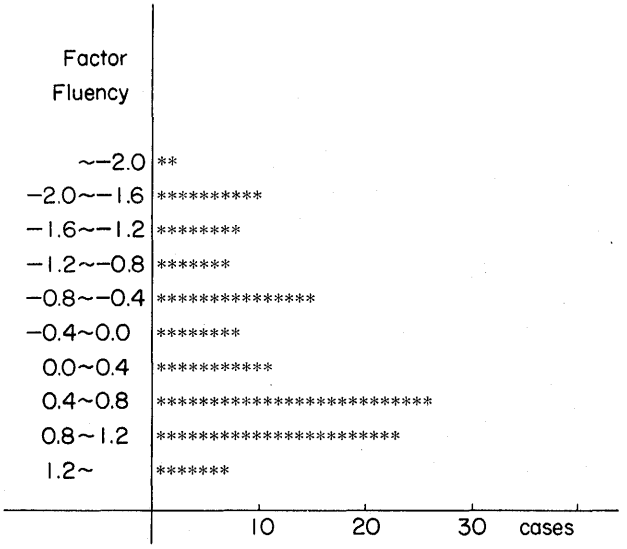

Fig. 1. Histogram of Factor "Fluency"

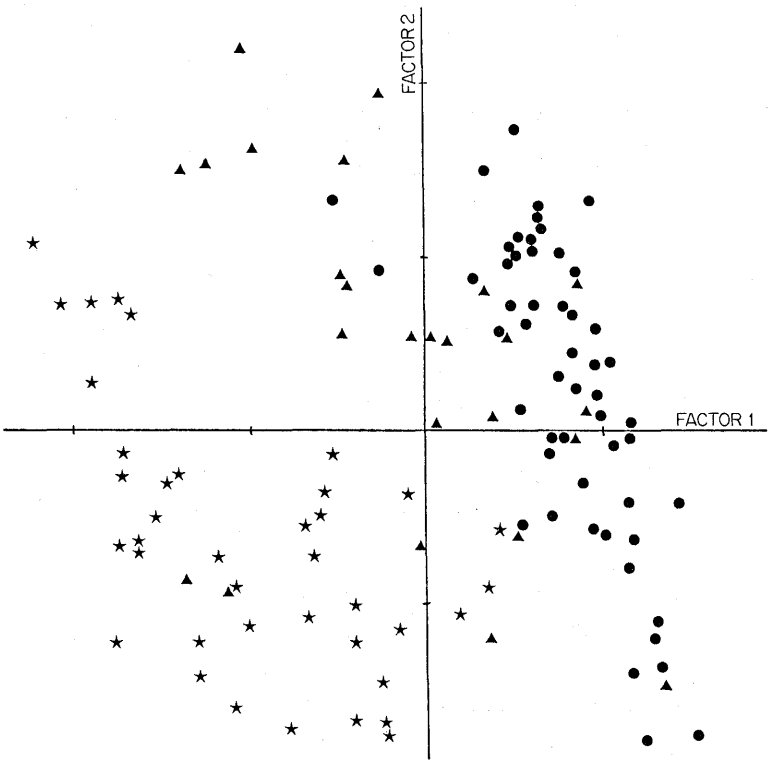

Fig. 2. Scattergram of 117 cases (A), (Circle: Fluent aphasia, Star: Non-fluent aphasia, Triangle: Intermediate group)

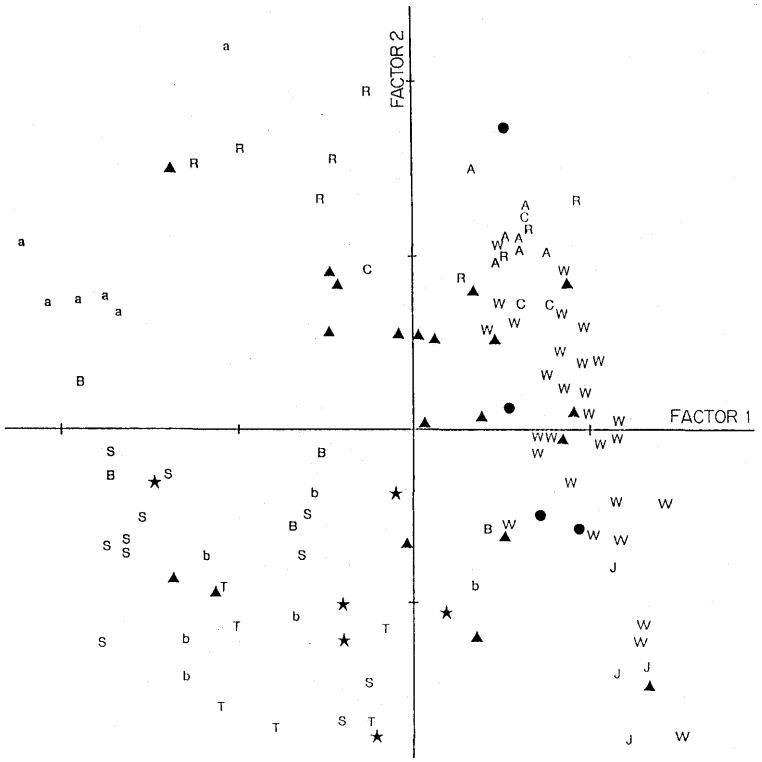

Fig. 3. Scattergram of 117 cases (B), (W: Wernicke, J: Neologistic Jargon, A: Amnestic, C: Conduction, R: Residual, T: Total, S: Severe Broca, B: Typical Broca, b: Atypical Broca, a: Mild Broca with Anarthria)

there is an intermediate category between the fluent and the non-fluent aphasia groups.

The factor scores of all cases were plotted on the two dimensional co-ordinate axes. Fig. 2 is a scattergram of 117 cases. The horizontal axis and the vertical axis show the factor score of Factor 1 "Fluency" and Factor 2 "Communicability" respectively. In this figure the cases of the fluent aphasia group are represented as the black circles; the cases of the non-fluent group as the stars; the intermediate group as the triangles. This scattergram shows clearly, that the cases of the fluent group occupy positions on the right side and the cases of the non-fluent group on the left side without overlapping, and that the triangles of the intermediate group are scattered between the areas of both groups.

It is worthy of notice that the cases of the intermediate group are more densely distributed in the upper side than in the lower side. This fact may be explained by our clinical experience that with regard to aphasia with severe disturbances of communicability we can easily distinguish between fluent and non-fluent aphasia, because fluent aphasias with low communicability are virtually always Severe Wernicke or Neologistic Jargonaphasias and non-fluent aphasias with low commu-

nicability are Severe Broca or Total Aphasias, as shown in Fig. 3. By contrast, on the upper side of the scattergram there is a wide range in the intermediate group between the fluent and the non-fluent group; That is, in the group of aphasias with slight disturbances of communication, the dichotomy of the fluent and non-fluent aphasias cannot be determined univocally.

Fig. 3 is also a scattergram of all the cases classified by the notions of classical taxonomy. On the right half of the figure, the area of the fluent aphasia group, Neologistic Jargonaphasias are situated on the lower side, a large Wernicke aphasia group is in the middle, and Conduction aphasia and Amnestic aphasia are on the upper side. On the left half, the area of the non-fluent aphasia group, the lower side is occupied by Total aphasia and Severe Broca aphasia, the upper side by Mild Broca aphasia with Anarthria. The cases of Residual aphasia with high communicability are located in the top portion of the figure. This distribution map of aphasias seems to be consistent with our clinical experience.

It can be concluded from our results that the speech symptoms derived from conversational speech of patients are as important as the result of test-batteries (e.g. SLTA), for understanding aphasic phenomena and classifying types of aphasias.

References

1) Goodglass, H. and Kaplan, E.: The assessment of aphasia and related disorders. Lea & Febiger, Philadelphia, 1972.
2) Hadano, K., Hamanaka, T., Ohigashi, Y. and Ohashi, H.: On 5 cases of neologistic jargonaphasia. Clinical Psychiatry (Seishin-Igaku) 26: 701–710, 1984 (in Japanese).
3) Miyake, I. and Yamamoto, K.: Statistical package "SPSS". Toyo-Keizai-Shinposha, Tokyo, 1976 (in Japanese).
4) Ohashi, H.: Clinical Neuropsychology. Igaku-Shoin, Kyoto, 1965 (in Japanese).
5) Poeck, K.: Klinische Neuropsychologie. Georg Thieme, Stuttgart, 1982.

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